TJD-J352-EP

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 992 682 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.04.2000 Bulletin 2000/15

(51) Int. Cl.^{7}: **F04B 27/08**

(21) Application number: **99119474.7**

(22) Date of filing: **30.09.1999**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **05.10.1998 JP 28274498**

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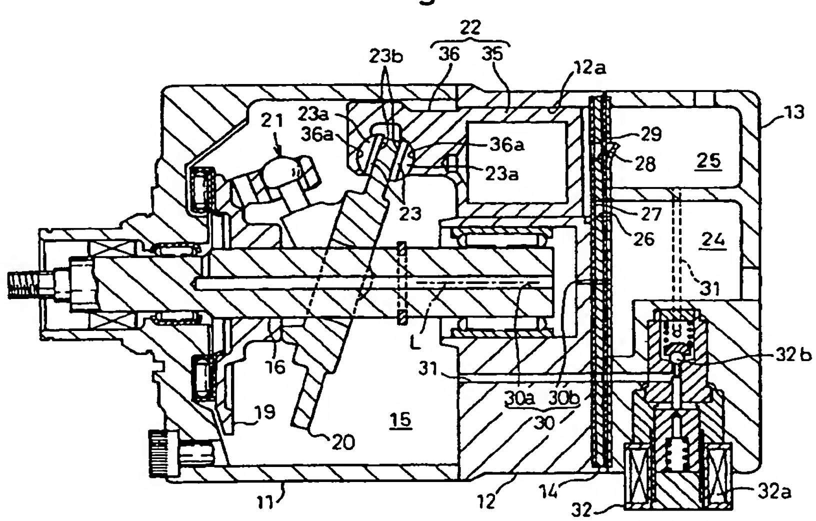
(54) **Piston compressor**

(57) A piston compressor in which a smooth linear reciprocal motion of the piston is maintained for a long period of time. A rotary motion of a swash plate or cam plate 20 is converted to a linear reciprocal motion of a piston 22 via a shoe 23 to compress a gas. The piston 22 has a neck 36 having a shoe seating surface 36a provided with a sprayed layer of a metal material to slide on a convex spherical surface 23a of the shoe 23.

Fig.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a piston compressor for compressing a coolant gas for a vehicle air conditioner, etc.

2. Description of the Related Art

[0002] The above-recited piston compressor has a piston connected to a cam plate in the form of a swash plate via a shoe. The swash plate is driven to rotate by a vehicle engine or other external drive means and the rotary motion is converted to a linear reciprocal motion of a piston via a shoe to compress a coolant gas. Therefore, an improved wear resistance must be provided on the sliding surface of the shoe that slides on the cam plate, the sliding surface of the shoe that slide on the piston, and the sliding surface of the piston that slides on the shoe, to prevent backlash from occurring at the sliding surfaces and to ensure a smooth linear reciprocal motion of the piston.

SUMMARY OF THE INVENTION

[0003] The object of the present invention is to provide a piston compressor in which a smooth linear reciprocal motion of the piston is ensured for a long period of time.

[0004] To achieve the object according to the present invention, there is provided a piston compressor having a rotary cam plate, a shoe and a reciprocal piston, in which a rotary motion of the cam plate is converted to a linear reciprocal motion of the piston via the shoe to compress a gas, wherein said piston compressor comprises a metal sprayed layer formed on at least one of a sliding surface of the shoe that slides on the cam plate, a sliding surface of the shoe that slides on the piston and a sliding surface of the piston that slides on the shoe.

[0005] The metal sprayed layer has a porous surface which facilitates penetration of a liquid lubricant to provide a reduced friction coefficient with respect to that of the original uncoated surface. Therefore, the metal-sprayed sliding surface of the shoe that slides on the cam plate, the metal-sprayed sliding surface of the shoe that slides on the piston, and/or the metal-sprayed sliding surface of the piston that slides on the shoe has an improved wear resistance to prevent a backlash from occurring either between the cam plate and the shoe and/or between the shoe and the piston, thereby maintaining a smooth linear reciprocal motion of the piston for a long period of time.

[0006] According to a preferred embodiment of the present invention, the metal sprayed layer contains a solid lubricant which facilitates a low friction sliding at the sliding surface of the shoe that slides on the cam plate, the sliding surface of the shoe that slides on the piston and/or the sliding surface of the piston that slides on the shoe.

[0007] According to another preferred embodiment of the present invention, prior to metal spraying, the original, uncoated sliding surfaces are pretreated by a surface roughening process to have an increased surface roughness, so that the adhesivity of the metal sprayed layer to the original sliding surface is improved to prevent exfoliation of the metal sprayed layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1 is a vertical cross-sectional view showing a variable displacement piston compressor; and

Fig. 2 is a perspective view showing a main part of the piston compressor shown in Fig. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] Figure 1 shows a piston compressor according to a preferred embodiment of the present invention. A front housing 11 is sealingly connected to the front end of a cylinder block 12. A rear housing 13 is sealingly connected to the rear end of the cylinder block 12 via a valve/port assembly 14. A crank chamber 15 is defined by the surrounding front housing 11 and cylinder block 12.

[0010] A rotary shaft 16 extends across the crank chamber 15 and is rotatably held between the front housing 11 and the cylinder block 12. The rotary shaft 16 is linked to a vehicle engine or an external drive mechanism via a solenoid clutch or other clutch mechanism. The rotary shaft 16 is thus driven to rotate by connecting the clutch mechanism during operation of the vehicle engine.

[0011] A rotary support 19 is fixed to the rotary shaft 16 within the crank chamber 15. A swash plate 20 forming a cam plate is made of an aluminum-based metal material. The swash plate 20 is held on the rotary shaft 16 so that it can slide in the direction of, and can tilt about, the axis L of the rotary shaft 16. A hinge mechanism 21 intervenes between the rotary support 19 and the swash plate 20. The intervening hinge mechanism 21 enables the swash plate 20 to tilt about, and to rotate integrally with, the rotary shaft 16. The inclination angle of the swash plate 20 is decreased when the radial center of the swash plate 20 is moved toward the cylinder block 12 and is increased when the radial center is moved toward the rotary support 19.

[0012] Plural cylinder bores 12a are formed in the cylinder block 12 at a selected interval around the axis L. Plural single-headed pistons 22 have a cylindrical

head 35 received in the corresponding cylinder bore 12a and have a neck 36 which engages with the peripheral portion of the swash plate 20 via a shoe 23.

[0013] Figure 2 shows a pair of opposite shoe seating surfaces 36a formed inside the neck 36. The shoe seating surfaces 36a are composed of parts of a single sphere. A pair of shoes 23 each has a substantially hemispherical shape, intervenes between the shoe seating surface 36a and the peripheral portion of the swash plate 20, has a convex spherical surface 23a fittingly received in the shoe seating surface 36a and has a flat surface 23b in fitting contact with the swash plate 20. The piston 22 is a casting, a forging, etc., of an aluminum-based metal material. The shoes 23 are a casting, a forging, etc., of an iron-based metal material. When the vehicle engine is operated, the swash plate 20 is driven via the rotary shaft 16 to rotate and the rotary motion is converted to a linear reciprocal motion of the piston 22 via the shoes 23.

[0014] A suction chamber 24 and a discharge chamber 25 are separately formed in the rear housing 13. A suction port 26, a suction valve 27, a discharge port 28 and a discharge valve 29 are formed in the valve/port assembly 14. When the piston 22 moves from the top dead center to the bottom dead center, a coolant gas is sucked from the suction chamber 24 through the suction port 26 and the suction valve 27 to the cylinder bore 12a. When the piston 22 is moved from the bottom dead center to the top dead center, the coolant gas is compressed in the cylinder bore 12a to a predetermined pressure and is discharged through the discharge port 28 and the discharge valve 29 to the discharge chamber 25.

[0015] A gas withdrawal passage 30 is composed of a passage 30a formed along the axis of the rotary shaft 16 and a through hole 30b formed through the cylinder block 12 and the valve/port assembly 14. The gas withdrawal passage 30 communicates the crank chamber 15 with the suction chamber 24. A gas supply passage 31 communicates the discharge chamber 25 with the crank chamber 15. A displacement control valve 32 is inserted in the gas supply passage 31 and has a solenoid 32a and a valve body 32b which is operated by energization and deenergization of the solenoid 32a to open and close the gas supply passage 31. The energization and deenergization of the solenoid 32a is computer-controlled corresponding to the refrigerating load, etc. Therefore, the opening degree of the gas supply passage 31 is adjusted by the valve body 32b to vary the pressure in the crank chamber 15, thereby adjusting the difference between the pressures in the crank chamber 15 and in the cylinder bore 12a, the pressures acting on the front and rear sides of the piston 22. As the result, the inclination angle of the swash plate 20 is varied to vary the stroke of the piston 22, thereby adjusting the discharge.

[0016] Specifically, when the solenoid 32a is deenergized, the valve body 32b opens the gas supply passage 31 to communicate the discharge chamber 25 with the crank chamber 15, so that a compressed coolant gas is supplied from the discharge chamber 25 to the crank chamber 15 through the gas supply passage 31 to raise the pressure in the crank chamber 15. When the pressure in the crank chamber 15 is thus raised, the inclination angle of the swash plate 20 is minimized to minimize the stroke of the piston 22, thereby minimizing the discharge.

[0017] When the solenoid 32a is energized, the valve body 32b closes the gas supply passage 31 and the pressure in the crank chamber 15 is allowed to be reduced depending upon an withdrawal pressure through the gas withdrawal passage 30. When the pressure in the crank chamber 15 is thus reduced, the inclination angle of the swash plate 20 is maximized to maximize the stroke of the piston 22, thereby maximizing the discharge.

[0018] In this example, the neck 36 of the piston 22 has both shoe seating surfaces 36a provided with a metal-sprayed layer. A metal spraying includes using a high speed flow of a pressurized gas to atomize a molten metal and to blow the atomized molten metal particles onto the shoe seating surface 36a. The thus deposited molten metal particles are rapidly solidified on the shoe seating surface 36a to cumulatively form a metal-sprayed layer or a metal coating Y on the surface 36a. Metals suitably used for the metal spraying include aluminum-based metal materials, copper-based metal materials, iron-based metal materials, etc. In Fig. 2, both shoe seating surfaces 36a are metal-sprayed, only one of which is represented by cross-hatching.

[0019] A metal suitably used for the metal spraying contains an additive of a solid lubricant, so that the metal-sprayed layer formed on the shoe seating surface 36a contains the solid lubricant. The solid lubricant may be molybdenum disulfide, carbon graphite, polytetrafluoroethylene or other fluorocarbon resin, tin, lead, etc.

[0020] The surface roughness of the original, uncoated shoe seating surface 36a has a substantial influence on the adhesivity of the metal-sprayed layer Y to the original shoe seating surface 36a. To provide an improved adhesivity of the metal-sprayed layer Y, the original shoe seating surface 36a must have an increased surface roughness. To this end, a pretreatment for metal spraying includes roughening the original shoe seating surface 36a by shot blasting. The shot blasting may be effected either by shot peening in which broken steel grains, rounded steel grains or abrasive grains are blown onto the shoe seating surface 36a, or by liquid honing in which a liquid containing abrasive grains is blown onto the original shoe seating surface 36a.

[0021] This embodiment provides the following advantages.

(1) The metal-sprayed layer Y has a porous surface

which facilitates penetration of a liquid lubricant to provide a reduced friction coefficient with respect to that of the original, uncoated shoe seating surface 36a. Therefore, the shoe seating surface 36a having the metal-sprayed layer has an improved wear resistance to prevent a backlash from occurring between the piston 22 and the shoe 23, thereby maintaining a smooth linear reciprocal motion of the piston 22 for a long period of time. It is also noted that a coolant gas contains a mist of a liquid lubricant, and therefore, the crank chamber 15 is fed with the liquid lubricant by a blow-by gas or by a coolant gas for displacement control introduced through the gas supply passage 31.

(2) The metal-sprayed layer Y contains a solid lubricant which facilitates a low friction sliding of the shoe seating surface 36a to provide a further improved wear resistance of the shoe seating surface 36a.

(3) The pretreatment for metal spraying includes shot blasting the original shoe seating surface 36a to provide an increased roughness of the original, uncoated shoe seating surface 36a, so that the adhesivity of the metal-sprayed layer Y to the original shoe seating surface 36a is improved to prevent exfoliation of the metal-sprayed layer Y.

[0022] The present invention may be also embodied as follows.

-- In the above-described example, the metal-sprayed layer is formed on the shoe seating surface 36a alone. In a modified embodiment, the metal-sprayed layer is formed on the convex spherical surface 23a of the shoe 23 alone, or on both the shoe seating surface 36a and the convex spherical surface 23a. The convex spherical surface 23a provided with the metal-sprayed layer has an improved wear resistance to prevent a backlash from occurring between the piston 22 and the shoe 23, thereby maintaining a smooth linear reciprocal motion of the piston 22 for a long period of time.

-- In another modified embodiment, the metal-sprayed layer is formed on the flat surface 23b of the shoe 23 alone or on both of the shoe seating surface 36a and the flat surface 23b. The flat surface 23b provided with the metal-sprayed layer has an improved wear resistance to prevent a backlash from occurring between the swash plate 20 and the shoe 23, thereby maintaining a smooth linear reciprocal motion of the piston 22 for a long period of time.

-- The metal-sprayed layer may be further formed on all the shoe seating surface 36a, the convex spherical surface 23a and the flat surface 23b.

-- The metal for metal spraying is advantageously an aluminum-based metal material containing silicon, preferably in an amount of 10 wt% or more, to provide a metal-sprayed layer Y with an improved strength to suppress exfoliation and damaging of the layer.

-- The piston 22 is preferably made of an iron-based metal material.

-- The shoe 23 is preferably made of an aluminum-based metal material.

-- The swash plate 20 is preferably made of an iron-based metal material.

-- The piston compressor may be a wave cam type which has a metal sprayed layer formed on at least one of a sliding surface of a shoe that slides on a cam plate in the form of a wave cam, a sliding surface of the shoe that slides on a piston and a sliding surface of the piston that slides on the shoe.

-- The piston compressor may be a double-headed type which has a metal sprayed layer formed on at least one of a sliding surface of a shoe that slides on a cam plate, a sliding surface of the shoe that slides on a double-headed piston, and a sliding surface of the double-headed piston that slides on the shoe.

[0023] As can be seen from the above-described embodiments, the present invention also provides a piston of a piston compressor in which a rotary motion of a cam plate 20 is converted to a linear reciprocal motion of a piston 22 via a shoe 23 to compress a gas, wherein the piston has a metal sprayed layer formed on a sliding surface 36a thereof that slides on the shoe 23.

[0024] This ensures a smooth linear reciprocal motion of the piston 22 for a long period of time.

[0025] The present invention further provides a shoe of a piston compressor in which a rotary motion of a cam plate 20 is converted to a linear reciprocal motion of a piston 22 via a shoe 23 to compress a gas, wherein the shoe has a metal sprayed layer formed on one or both of a sliding surface 23b thereof that slides on the cam plate 20 and a sliding surface 23a thereof that slides on the piston 22.

[0026] This also ensures a smooth linear reciprocal motion of the piston 22 for a long period of time.

[0027] As described herein, the present invention provides a piston compressor in which backlash is prevented from occurring at a sliding surface between a cam plate and a shoe and/or at a sliding surface between a shoe and a piston, thereby ensuring a smooth linear reciprocal motion of the piston for a long period of time.

Claims

1. A piston compressor having a rotary cam plate, a shoe and a reciprocal piston, in which a rotary motion of the cam plate is converted to a linear reciprocal motion of the piston via the shoe to compress a gas, wherein said piston compressor comprises a metal sprayed layer formed on at least one

of a sliding surface of the shoe that slides on the cam plate, a sliding surface of the shoe that slides on the piston and a sliding surface of the piston that slides on the shoe.

2. A piston compressor according to claim 1, wherein said metal sprayed layer contains a solid lubricant.

3. A piston compressor according to claim 1 or 2, wherein at least one of said sliding surfaces on which said metal sprayed layer is formed is surface-roughened.

Fig.1

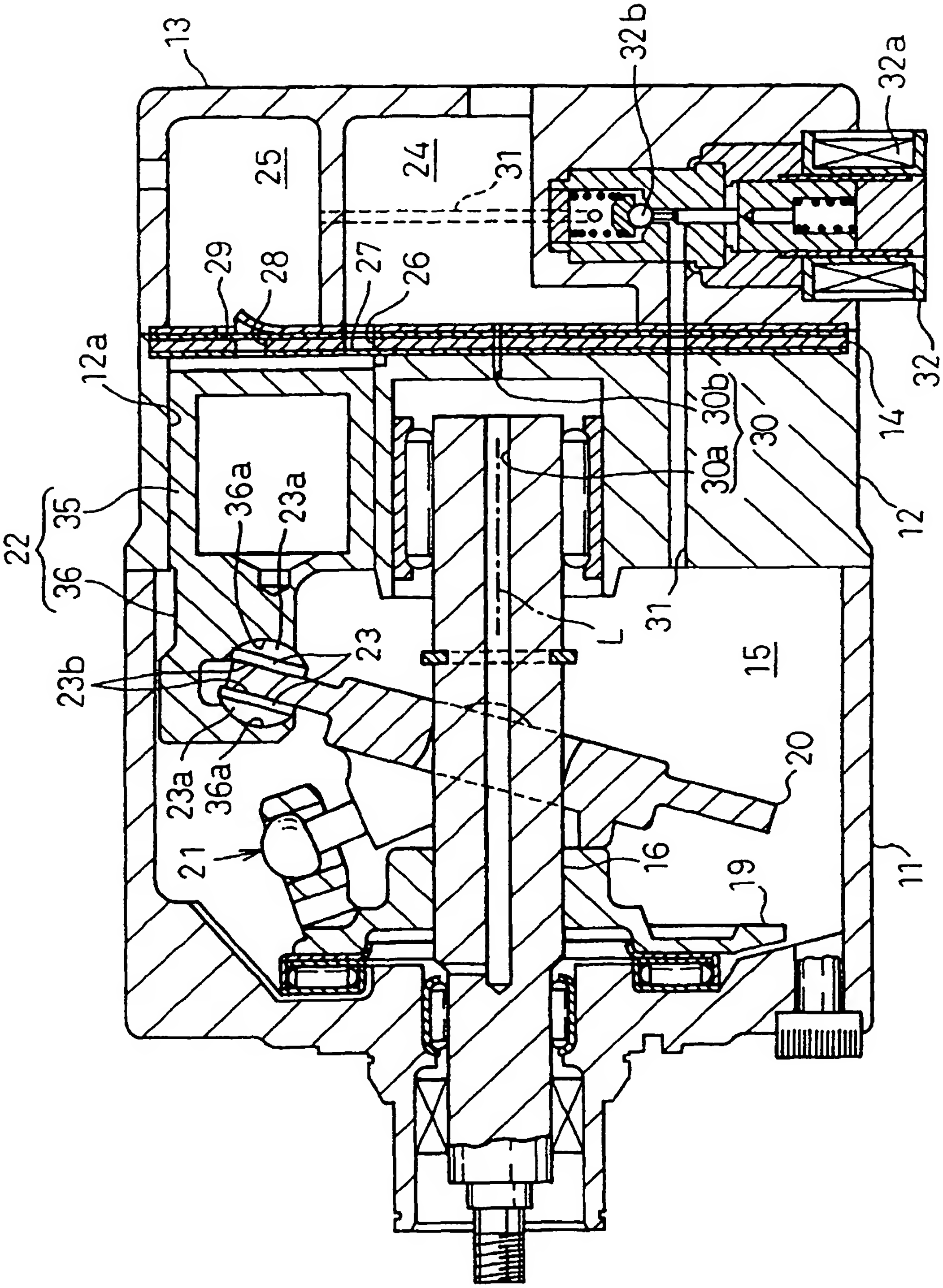
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Fig. 2